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Decadal Status of Pathotypes Distribution and Rusts Resistance Screening in Breeding Materials against Black and Brown Rusts of Wheat

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ABSTRACT

Evolution of new virulent races/pathotypes by mutation which can overcome existing resistant cultivars make the management of rusts a challenging task. The pattern of dynamism of black and brown rusts pathotypes in Gujarat during the last decade revealed that out of seventy five samples analyzed primarily four pathotypes (majority were 11 and 40A) were identified for black rust while two pathotype viz. 21R55 (104-2), and 121R63-1 (77-5) were overarching in their presence followed by 77-11, 77, 104-B, 104-3, 77-6, 77-1, 77-2, and 77-8 in the range of 1 to 18 per cent for brown rust. Screening of irrigated and rainfed wheat breeding materials of different stations for both black and brown rusts under artificial epiphytotic conditions in last decade at Vijapur suggested that total entries including both irrigated and rainfed wheat of 2871, 2775, 404, 1881, and 117 of Vijapur, Junagadh, Anand, Arnej, and Dhandhuka respectively, were screened so far accounted from 2007-08. It was cleared that most of the screened stations breeding materials were characterizing a good source of resistance which were depicted by resistance percentage of 83.80, 62.48, and 33.33 in irrigated wheat entries of Vijapur, Junagadh and Anand respectively while 34.56 and 35.12 per cent of resistance in rainfed wheat entries of Dhandhuka and Arnej against black rust. Although, 91.71, 85.30, and 45.30 in irrigated wheat entries of Vijapur, Junagadh, and Anand while 49.50 and 48.76 per cent of resistance were depicted in rainfed wheat of Dhandhuka and Arnej against brown rust.

Key words: *Adult plant resistance, Black rust, Brown rust, Pathotype/race, Seedling resistance.*

INTRODUCTION

Black/stem caused by *Puccinia graminis* f.sp. *tritici* Eriks. and brown/leaf rusts caused by *Puccinia triticina* Erisk. Are belongs to family Pucciniaceae, order Uredinales, and class Basidiomycetes of Basidiomycotina. The fungus is heterocious in nature, alternating with a telial host in Poaceae and an aecial host in Berberidaceae, and macrocyclic producing five types of spore. An overview of losses in the USA from 1918 to 1976, reported that yield reductions of 50% in epidemic years due to both black and brown rusts[22]. Different estimates have been published about the losses caused due to wheat rusts in India from time to time. The annual loss in wheat from rusts valued of about Rs. 40 million[5].

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A total loss of about Rs. 60 million annually in wheat and barley were reported[15]. According to Prasada nearly one million tonnes of wheat costing about Rs. 392 million were damaged during 1958-59 [20]. Another report revealed that maximum yield losses due to brown rust were 30-40 per cent mostly due to reduction in 1000 grain weight[21]. In India, the Central and Peninsular southern part where the warmer temperature prevails in growing season are prone to black and brown rusts, but brown rust mostly confined in wheat belt of Northern Hill Zone and Northern Pain Zone[12]. But under Indian conditions, there is no role of alternate host in the completion of its life cycle for both rusts. Since in southern part of India, in Nilgiri Hills the susceptible hosts remains round the year, where environmental conditions favor pathogen survival and from where urediniospores are blown to other parts of India with cyclonic winds and completes its dissemination for black rust[14,16]. While brown rust is contributed by Himalayas of northern hills. Besides, the pathogen has ability to multiply rapidly resulting in trillions of urediospores production along with long distance airborne urediospores dispersal and also evolution of new race/pathotype by mutation makes management strategy a challenging task for rusts[27]. Identification of pathotypes, evaluation for rusts resistance, anticipatory breeding programme with deployment of resistant cultivars is a time tested strategy to manage wheat rusts. However, the rust's pathogen being out smarted and new virulent pathotypes emerged which could overcome the novel rust resistance genes. But, genetic resistant is the most efficient, economical and environmentally friendly approach to control rusts[11,13,25]. So, for effective management of both rusts, identification of new sources for resistance and appropriate gene deployment strategies based on regional racial pattern are needed. Although, evolution of new physiological races/pathotypes resulting to overcome the effect of current resistance cultivar, has compel for screening of large number of wheat germplasms, breeding materials, cultivars and advance lines for their reaction to both black and brown rusts under epiphytotic condition. Therefore, analyzing genetic background for the presence of resistance genes in resistant cultivars as well as in breeding lines, germplasms etc. can provide great information for exploring new sources of resistance[9]. Understanding effective resistance genes to black and brown rusts and their characteristics in wheat cultivars is one of the most important premises for an effective application and distribution of the resistance source for comprehensive control of wheat rusts[6]. Utilization of race non-specific resistance which is mainly polygenic has often been described as slow rusting or partial resistance and more durable than race specific resistance[10,17]. Slow rusting parameters can be used for grouping of different cultivars based on their resistance reaction[23,24]. Therefore, there is an urgent need for identification of new sources of durable resistance and enhancement of genetic resistance to both rusts. This paper emphasized on decadal research work on status of pathotypes distribution for both rusts and screening of rusts resistance in both irrigated and rainfed wheat breeding materials under artificially created epiphytotic condition in last decade at Wheat Research Station, Vijapur, Gujarat, India.

MATERIAL AND METHODS

Rusts pathotype analysis

Rusts pathogen are dynamic in nature and evince innumerable oddities. So, each one is known to have many pathotypes and emergence of new pathotype by mutation generally renders resistant variety to susceptible one. Hence, dynamism of pathotypes has tangible repercussions. To monitor the variability in rusts pathotype distribution and as well as detection of new pathotypes emergence and field response of existing released varieties, periodic rusts samples were randomly collected through mobile surveys depending upon location and transportation facility. The samples were collected from regular crop as well as from off-type plants in regular crops as they also serve as source of inoculum. The samples showing typical rust symptoms collected from different location were brought to the laboratory. Then, small bits of each rust infected sample were dried overnight at room temperature followed by wrapping in paper envelope and sent to Regional Station, Indian Institute of Wheat and Barley Research, Flowerdale, Shimla for race analyses. On each sample, information such as name of person who collected the sample, type of rust, date and place of collection, details of host/variety etc. were given.

Resistance screening of station materials under epiphytotic condition

The materials under study for field based assessment include breeding materials of different stations of Gujarat with a total of 2871, 2775, 404, 1881, and 117 for Vijapur, Junagadh, Arnej, Dhandhuka, and Anand respectively in last decade (Table 3). Two rows of one meter line for each entry were sown which were surrounded by two rows of infector lines in all borders comprising mixture of six susceptible varieties *viz.* Agra Local, A-9-30-1, A-206, Kharachia, Lok 1, and Lal Bahadur. The main purpose of sowing infector lines was to maintain high inoculum pressure and multiplication of rusts during the season. Two rows of infectors were also sown after each twenty entry so as to check inoculums dispersal from the inoculated infector lines. In order to create an epiphytotic condition, which is an ideal condition for resistance screening of entries at field condition, inoculation in infector lines for both black and brown rusts have been practiced at boot leaf and tillering stage respectively. The predominant pathotypes of both the rusts viz. 40A, 40-1 and 11 for black and 77-2, 77-5 and 104-2 for brown rust, received from Flowerdale, Shimla, were first established on infectors sown in micro-plots then inoculum suspension was prepared for inoculation on infectors lines in main screening programme. For inoculation of black rust uredospores, the plants on which the boot leaf has emerged were selected first. The inoculum suspension has been prepared after collecting black rust uredospores with the help of camel hair brush and later on dissolved in sterile distilled water followed by adding of few drops of Tween 20 for uniform distribution of uredospores as emulsifying agent. The suspension was injected into the second inter-nodal stem with the help of hypodermal syringe until the whole stem gets filled with inoculum which will be indicated by the coming out of droplets of suspension from the tip of the plants. For brown rust, the inoculum suspension has been prepared after collecting brown rust uredospores with the help of camel hair brush then the uredospores were dissolved in sterile distilled water followed by adding of few drops of Tween 20 for uniform distribution of uredospores as emulsifying agent. The prepared inoculums suspensions were filtered in muslin cloth to remove any dirt particles if present. Few plants with excellent growth (mostly 2’x1’area) were selected then spraying of water was first practiced so as to remove any dust particles and inert material from leaves surface, followed by spraying of inoculum suspension by using hand operated sprayer. The inoculated area was covered with plastic polythene bag designed especially for this purpose (Size:2’x1’x1’) so as to maintain a sufficient humidity inside. This procedure was normally followed late in the evening when the temperature was low and there were sufficient moisture in the soil. On next day morning, the polythene bags were gently removed with due care so that the soil does not fall on the inoculum sprayed plants. The recording of observations has been started after the first emergence of symptoms of the disease by recording the severities as per cent infection from the individual lines according to modified Cobb’s scale (Table 1) upto adult stage in order to monitor disease progress[18]. The severity was recorded by visual observation; usually 5 per cent interval was used from 5-20 per cent and 10 per cent intervals in between 20-100 per cent severity. The combination of severity and reaction/infection types were recorded at the same time at regular intervals.

RESULTS AND DISCUSSION

Outline of rusts pathotypes distribution in Gujarat

For black rust, primarily four pathotypes were identified out of seventy five samples analyzed in last decade but majority were 11 and 40-A. While for brown rust, two pathotypes *viz*. 21R55 (104-2), and 121R63-1 (77-5) were overarching in their presence indicating these pathotypes establish, multiply and spread very fast under the prevailing environmental conditions. The other pathotypes *viz*. 77-11, 77, 104-B, 104-3, 77-6, 77-1, 77-2, and 77-8 were reported in the range of 1 to 18 per cent of the samples suggesting that there was great diversity in brown rust pathotypes distribution in agro climatic condition of Gujarat. So far, no any new virulent pathotype have been reported from Gujarat including Ug99 which is a great concern of threat in worldwide wheat production. The consolidated information on the number of isolate analyzed for both black and brown rusts during last decade is summarized below in table 2 and 3 respectively. Similar finding were also reported by studying population differentiation of wheat leaf rust in South Asia and suggested that pathotypes 12-1, 12-3, 12-6, 12-7, and 12-8 shared more than 80% similarity[19]. Likewise pathotypes 77-2, 77-3, 77-6, 77-A, and 77-A-1 shared more than 70% similarity, which indicated that they might have evolved from genetically similar ancestors[4] and concluded that high diversity among the pathotypes might be the result of evolution and mutation in the pathogens along with the long-term cultivation of wheat varieties in different wheat-growing zones of the country. Brown rust pathotypes 12-2, 77-5, and 104-2 were identified in more than 86% out of total 622 samples analysed from fourteen states[2]. Thus, the regular detection of rusts pathotypes and the resulting information would be valuable for managing rusts.

Table 1: Modified Cobb's scale for rusts

Reaction type	Response value	Category	Visible symptoms
0	0.0	Immune	No visible infections
R	0.2	Resistance	Necrotic areas with or without uredia
MR	0.4	Moderately resistance	Necrotic areas with small uredia
MS	0.8	Moderately susceptible	Medium uredia with no necrosis but some chlorosis
S	1.0	Susceptible	Large uredia with no necrosis and no chlorosis
X	0.6	Intermediate	Variable sized uredia with necrosis or chlorosis and fully susceptible

Table 2: Status of black rust pathotype distribution in Gujarat in last decade

S.No.	Year	No. of sample analyzed	Pathotype identified			
			11 (79G31)	40A (62G29)	40-1 (62G29-1)	40-3 (127G29)
1	2006-07	--	--	--	--	--
2	2007-08	1	--	1	--	--
3	2008-09	--	--	--	--	--
4	2009-10	--	--	--	--	--
5	2010-11	--	--	--	--	--
6	2011-12	8	--	8	--	--
7	2012-13	15	15	--	--	--
8	2013-14	8	1	5	1	1
9	2014-15	26	24	2	--	--
10	2015-16	17	17	--	--	--
Total		**75**	**57**	**16**	**1**	**1**

Table 3: Status of brown rust pathotype distribution in Gujarat in last decade

SN	Year	No. of sample analyzed	Pathotype identified													
			77 (45R31)	77-1(109R63)	77-2(109R31-1)	77-3(125R55)	77-5(121R63-1)	77-6(121R55-1)	77-11(125R28)	104-2(21R55)	104-3(21R63)	104A(21R31)	162 (93R07)	104B(29R23)	162-2(93R39)	136A(93R15)
1	2006-07	23	--	--	--	--	8	--	--	7	8	--	--	--	--	--
2	2007-08	1	--	--	1	--	--	--	--	--	--	--	--	--	--	--
3	2008-09	9	--	3	--	--	2	--	--	--	1	1	--	--	--	2
4	2009-10	13	--	--	--	--	1	--	12	--	--	--	--	--	--	--
5	2010-11	36	3	2	--	--	13	--	--	12	3	--	--	3	--	--
6	2011-12	1	--	--	--	--	1	--	--	--	--	--	--	--	--	--
7	2012-13	6	--	--	--	1	1	2	1	--	1	--	--	--	--	--
8	2013-14	19	--	--	2	--	5	--	--	10	--	--	1	--	1	--
9	2014-15	5	--	--	--	--	--	--	--	5	--	--	--	--	--	--
10	2015-16	2	--	--	--	--	1	--	--	1	--	--	--	--	--	--
11	**Total**	**115**	**3**	**5**	**3**	**1**	**32**	**2**	**13**	**34**	**13**	**1**	**1**	**3**	**1**	**2**

Screening of entries for black and brown rusts resistance in last decade at Vijapur

A large number of irrigated wheat breeding materials of Vijapur, Junagadh, Anand, and rainfed wheat entries of Arnej and Dhandhuka had been screened under artificial epiphytotic condition for ensuring effective screening of resistant entries against black and brown rusts. Total irrigated wheat entries of 2871, 2775, and 117 of Vijapur, Junagadh, and Anand respectively (Table 4), while total rainfed wheat entries of 1881 and 404 of Dhandhuka and Arnej, had been screened so far in last decade accounted from 2007-08 against black and brown rusts (Table 5). It reveals that most of the screened breeding materials were characterizing a good source of resistance which were depicted by resistance percentage of 83.80, 62.48, and 33.33 in irrigated wheat entries of Vijapur, Junagadh, and Anand respectively (Table 4), while resistance percentage of 34.56 and 35.12 in rainfed wheat entries of Dhandhuka, and Arnej (Table 5) against black rust. Although, resistance percentage of 91.70, 85.30 and 45.30 respectively in irrigated wheat entries of Vijapur, Junagadh and Anand (Table 6) while 49.50 and 48.76 per cent of resistance in rainfed wheat entries of Dhandhuka and Arnej (table 7) against brown rust (But original year-wise rusts score are not shown since it is unfeasible to put 10 years data for all tested entries). Remaining entries in percentage of 16.20, 37.62, 66.67, 65.44, and 64.85 in Vijapur, Junagadh, Anand, Dhandhuka, and Arnej respectively, were observed as susceptible to black rust in both irrigated and rainfed wheat breeding materials while 8.30, 14.70, 54.70, 50.50, and 51.24 per cent in Vijapur, Junagadh, Anand, Dhandhuka, and Arnej respectively, were observed as susceptible to brown rust in both irrigated and rainfed wheat breeding materials. Thus, so far screened wheat materials posses a good percentage of resistance which could an important source for resistance against black and brown rusts in wheat resistance breeding programme. So, the centre act as a nodal centre for the screening of entries for breeding materials against the predominant pathotypes of both black and brown rusts confined in Gujarat which make sure that any material which has been screened out from this centre could be the best genotypes for further use in wheat resistance breeding programme. Similar findings were reported while evaluating 28 wheat germplasms for the identification of resistant sources to brown rust at field condition under artificially inoculated epiphytotic condition[7]. Ahmad reported that there was a considerable amount of genetic variation among various wheat germplasm ranging from immune to susceptible response[1]. Evaluation of 44 wheat cultivars for brown rust resistance reported that 14 lines showed seedling resistance against 77-5 also showed adult plant resistance against pathotypes 77-5, 77-2, and 104-2[26]. Confirmation of brown rust resistance in 30 exotic wheat germplasm accessions at both seedling and adult stage reported that three accessions viz. EC 635627, EC 635721, and EC 664244 showed resistant at seedling stage while twenty nine accessions were characterized as resistant at adult plant stage with their low values of area under disease progress curve (AUDPC)[8]. Another report also supported the finding where 44 advanced breeding lines and released varieties of wheat were screened against different pathotypes of brown rust both at seedling and adult plant stage in controlled polythene house conditions and also postulated some seedling and adult plant resistance genes in these tested lines which can be useful in increasing genetic diversity and avoiding epiphytotic development of brown rust on wheat[3].

Table 4: Status of black rust resistance in irrigated wheat entries screened in last decade

S. N.	Year	Vijapur			Junagadh			Anand		
		No. of entries	R	MR	No. of entries	R	MR	No. of entries	R	MR
1	2007-08	212	81	106	294	126	105	--	--	--
2	2008-09	352	95	151	268	23	79	--	--	--
3	2009-10	334	97	158	278	51	150	--	--	--
4	2010-11	338	113	155	286	113	98	--	--	--
5	2011-12	302	138	82	298	172	42	--	--	--
6	2012-13	327	88	114	279	40	64	--	--	--
7	2013-14	324	171	89	300	137	46	--	--	--
8	2014-15	370	214	71	281	139	61	--	--	--
9	2015-16	298	186	54	259	114	33	14	4	3
10	2016-17	312	207	36	232	50	97	103	6	26
Total		**2871**	**1390**	**1016**	**2775**	**956**	**775**	**117**	**10**	**29**

Table 5: Status of black rust resistance in rainfed wheat entries screened in last decade

S. N.	Year	Dhandhuka			Arnej		
		No. of entries	R	MR	No. of entries	R	MR
1	2007-08	196	22	68	--	--	--
2	2008-09	217	9	96	74	7	26
3	2009-10	225	36	55	99	9	43
4	2010-11	206	0	20	--	--	--
5	2011-12	199	17	21	42	3	0
6	2012-13	171	26	25	35	1	7
7	2013-14	172	26	30	35	1	8
8	2014-15	177	33	52	49	7	19
9	2015-16	171	34	16	35	0	1
10	2016-17	147	36	28	35	6	4
Total		**1881**	**239**	**411**	**404**	**34**	**108**

Table 6: Status of brown rust resistance in irrigated wheat entries screened in last decade

S. N.	Year	Vijapur			Junagadh			Anand		
		No. of entries	R	MR	No. of entries	R	MR	No. of entries	R	MR
1	2007-08	212	106	78	294	167	96	--	--	--
2	2008-09	352	146	129	268	156	100	--	--	--
3	2009-10	334	160	121	278	150	104	--	--	--
4	2010-11	338	188	120	286	148	94	--	--	--
5	2011-12	302	210	52	298	169	45	--	--	--
6	2012-13	327	228	77	279	175	80	--	--	--
7	2013-14	324	248	32	300	229	27	--	--	--
8	2014-15	370	308	21	281	221	42	--	--	--
9	2015-16	298	243	24	259	167	38	14	8	3
10	2016-17	312	120	22	232	119	40	103	23	9
Total		**2871**	**1957**	**676**	**2775**	**1701**	**666**	**117**	**31**	**22**

Table 7: Status of brown rust resistance in rainfed wheat entries screened in last decade

S. N.	Year	Dhandhuka			Arnej		
		No. of entries	R	MR	No. of entries	R	MR
1	2007-08	196	78	74	--	--	--
2	2008-09	217	16	81	74	0	28
3	2009-10	225	37	56	99	25	26
4	2010-11	206	1	24	--	--	--
5	2011-12	199	24	26	42	9	4
6	2012-13	171	94	49	35	25	8
7	2013-14	172	54	21	35	9	3
8	2014-15	177	87	53	49	29	15
9	2015-16	171	55	25	35	0	3
10	2016-17	147	54	22	35	10	3
Total		**1881**	**500**	**431**	**404**	**107**	**90**

CONCLUSION

Due to the evolution and dispersal of highly virulent new races of rusts has once again become a threat to global wheat production. But, proper utilization of race specific resistance in combinations with focusing on breeding program for developing resistant varieties which have non-race specific/adult plant resistance might be able to mitigate from rusts. So, the basic aim should be reducing the selection pressure of pathogen for its virulence. Thus, more research in the areas of both applied and basic research might able to receive high priority to combat both black and brown rusts of wheat. Therefore, there is a need for better understanding of dynamics of pathotypes population over time and space, designing breeding strategies at the regional level, scientific awareness in deployment of available resistance sources for improving the status of wheat resistance breeding programme against black and brown rusts.

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